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AGRICULTURAL MEMORANDUM NO. 901

WIND AND SALT DAMAGE TO CROPS ON THE CLEVELAND COAST

The coastal area of Cleveland is one of the windiest arable areas in the UK. In Climatological Memorandum 79 maps of hourly mean wind speed are given for UK. Two of these are with this memo. One shows the speeds which are exceeded for 50% of the time (ie. the average speed) and the other shows the speed which is exceeded for 10% of the time (ie. for 880 hours per year). These maps are valid for a height of 10 m above open level terrain with a gust ratio (= gust speed/mean speed) of 1.6 and for altitudes between 0 and 70 m.

In the Memo 79 procedures are given for correcting the map values for altitude and gust ratios. The map values for the Cleveland coast are about 5.4 m/sec (50% speed) and 10.0 m/sec (10% speed). Much of the coastal area is about 150 m above sea level with a cliff coastline with some crops grown on top of the cliff and on bare hills within a mile of the cliff top. If we apply the height correction we obtain speeds of 5.7 m/sec and 10.6 m/sec, and if we apply the gustiness correction for a coastal site with winds off the sea we obtain 6.4 m/sec (50% value), and 12.0 m/sec (10% value).

These are quite high speeds and are high enough for some direct effects to be obvious. For example Russell and Grace (1978) exposed grasses to wind speeds in the range 1 to 10 m/sec in a wind tunnel and found large increases of leaf damage in this range of speed, accompanied by reductions in the rate of leaf extension of about one third. The lengths of mature leaves were also reduced by about a third. Well sheltered lowland inland fields may have 50% speeds of 2 to 3 m/sec as compared with 6.4 m/sec on the coast, and a rough calculation suggests this may cause a reduction of leaf area at the coastal site by 15%, as well as causing more leaf damage.

Observations in May 1980

Crops of winter and spring cereals were inspected at the places numbered 1 to 4 on the map.

Site 1. This farm is situated next to the sea at elevations between 500 and 700 ft. In general the area is what would be called exposed, especially to winds between north west and south east, which also have a long sea track. The western part of the farm is also exposed to winds from between south west to north west. A few stone walls 3-5 ft tall separate the fields.

March sown spring cereals showed signs of leaf browning, but no breakage. It was clear that part of the crop which was growing on the south side of a NW-SE oriented wall was taller with less browning. The weeds were larger as well in the more sheltered zone. One field facing north, right on the cliff edge had suffered blow conditions.

IFH2B

Some winter barley growing at 670-700 ft altitude appeared to be suffering from the environment. The leaf area was low, there were only a few tillers per plant and the growth habit was prostrate. Leaf browning and tearing was extensive. By contrast some winter barley on the gently sloping south side of the hill between 600 and 650 ft altitude was much taller, better tillered and with less browning. This crop was growing in a field on a gently sloping concave area and was surrounded on all sides by stone walls.

Other winter wheat crops were inspected at sites near to site 1. Similar features of leaf browning were seen.

Site 2. This is an arable area on the western edge of the North York Moors with crops growing on a rolling plateau at elevations between 750 and 1000 ft. The site is about 30 miles from the sea and exposed to wind from any direction. Rough measurements of wind speeds on the same day at sites 1 and 2 showed that the speeds are similar at sites 1 and 2 (12.5.80 15-18 mph mean with gusts to 22-25 mph at 2 m height).

The winter wheat showed clear signs of wind damage. All crops were laid down from approximately the NE direction. There was a small amount of browning on the leaf edges, and many leaves had broken across the middle and hung limply. Some leaves had lost the end portion of the leaf entirely. Spring cereals at 3-4 leaf stage had avoided any damage like this.

Sites 3 and 4. These are lowland sites in the Vale of York. Site 3 is about 30 ft altitude and although there are large flat fields the country is also well wooded. Site 4 is about 6 ft altitude, generally flat with only a few trees and low hedges. Winter barley/wheat crops showed some browning of the leaf margins only, the shrivelling of the end inch or so was not present with these crops. There was virtually no leaf breakage.

The Effects of Wind and Salt on Plants

The following is a summary based on "Plant Response to Wind" by Grace and "Shelterbelts and Windbreaks" by Caborn.

Wind has been observed to have these effects on plants:-

1. Leaf margins become brown.

2. Leaf tips are bruised.

3. Leaves become folded. The amount of folding is governed by the degree of turbulence in the airstream; very gusty winds cause more folding.

4. Leaves become torn or broken off.

5. The leaf surface becomes abraded, either by leaves rubbing together or by the action of sand carried by the wind.

In addition to these mechanical effects there is a physiological response caused by dehydration. For plants with a low stomatal resistance (ie. well supplied with water) transpiration increases as the wind speed increases. The combination of dry air and strong wind can cause rapid transpiration which may cause browning of the leaves. It also appears to reduce the cell size as the leaves grow and so reduces the rate of leaf extension and the ultimate leaf length.

Salt also causes dehydration since it is a hygroscopic substance. While most deposition occurs near the coast some summer gales in S. England have been known to cause salt damage 25-55 km inland. In general the amount of salt caught on plants is proportional to windspeed and inversely proportional to distance from the coast. Droplets are captured more effectively than dry particles, and also wet leaves can capture more particles. Rougher and taller crops also tend to capture more salt, and the uptake of salt is greater for leaves that are already wounded by wind or sand action. Deposition is also highest at the edge of the leaf which faces into wind.

An abrupt increase in airborne salt concentrations has often been observed when the wind increases from about 6 to 7.5 m/s. This is due to a change of sea state from non-breaking to breaking waves (white caps). Hence we should expect winds more than 20 kt to produce more marked salt damage.

Analysis of Whitby Winds

Observations of wind speed and direction are available every 3 hours from 1962. This data for the months of March, April and May were sorted for winds above 15 kt and above 25 kt and for directions between north west and south east (through north). Winds above 15 kt should produce some salt damage, while winds above 25 kt should cause considerable damage. The table shows the percentage of time for each month with winds above these limits.

Some points to be mentioned are:-

1. April is as bad as March. The average per cent of total time above 15 kt for winds off the sea is about 15% for both months, and the variation about the mean is similar. For winds above 25 kt April is not a lot better than March.

2. In the period between 1962 to 1980 there were three Marches with no reports of wind above 25 kt, and only two Aprils.

3. May is markedly better than April. The mean per cent of time above 15 kt falls to 10%, and 10 Mays did not record any wind above 25 kt.

For the strongest winds (above 25 kt) we find that the commonest direction in the 'danger sector' between north west and south east, is between north west and north. These north west to north winds occupy 45% of all the strong winds in the 'danger sector' during March, 85% in April and 81% in May. It could be argued that north west winds do not have a long sea fetch. However, the trajectory of the air is important and quite often a "low" in the North Sea will have cyclonically curved isobars which match the shape of the east coast of UK quite well, and so in effect give a long sea fetch.

Winds in 1980

Wind data for Whitby is not available on computer archive until the end of the year, but data for Spurn (5 on the map) has been extracted from the Daily Weather Report for comparison and is shown in the table. It would appear that March and April were not unusual, but that the May total of winds above 15 kt was far in excess of anything since 1962.

Conclusion

Strong winds are a common feature of the north east coast arable area. The winds measured at Whitby show that April is no better than March, and that winds over

25 kt which would be expected to cause serious salt damage, have occurred in most Marches and Aprils since 1962. Spring crops which are sown after the first week in April would be expected to avoid the worst of this damage.

There is also the less obvious reduction of leaf area due to wind. Wind speeds on the coast could be twice those at sheltered inland districts and cause a slower build up of leaf area in spring, a reduced maximum leaf area and a reduced yield.

Any suggestions or comments should be made to the author.

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WHITBY COASTGUARD

PERCENTAGE FREQUENCY OF WINDS ABOVE 15 kt BETWEEN NW AND SE (THROUGH N)

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
MARCH	23.4	9.7	34.3	8.0	8.9	3.2	12.0	27.2	15.9	15.6	6.5
APRIL	22.4	13.1	11.9	13.5	25.3	21.9	10.1	12.8	24.8	10.0	17.2
MAY	20.8	7.1	1.0	15.7	8.8	13.6	12.5	12.5	9.7	7.3	18.5

	1973	1974	1975	1976	1977	1978	1979	1980*	Mean 1962-79
MARCH	10.2	16.1	28.0	13.3	8.4	6.4	19.2	18.7	14.8
APRIL	27.0	10.8	14.9	10.4	12.3	11.3	16.2	15.8	15.9
MAY	10.5	13.7	18.5	3.6	2.0	8.4	3.6	32.5	10.4

PERCENTAGE FREQUENCY OF WINDS ABOVE 25 kt BETWEEN NW AND SE (THROUGH N)

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
MARCH	4.5	1.7	14.6	0.4	4.2	0.0	4.8	8.5	8.2	4.0	0.0
APRIL	0.8	4.8	0.5	3.9	0.8	5.3	1.3	3.7	5.9	0.0	5.0
MAY	9.8	0.0	0.0	0.4	0.0	0.8	0.0	1.6	0.0	0.0	2.8

	1973	1974	1975	1976	1977	1978	1979	1980*	Mean 1962-79
MARCH	1.2	2.8	10.4	0.8	0.0	2.4	7.6	4.9	4.2
APRIL	12.0	0.0	5.8	0.8	2.0	2.5	2.5	1.7	3.2
MAY	0.4	0.0	1.2	0.8	0.0	1.2	0.0	0.0	1.1

*Data for Spurn Point

REFERENCES

Caborn J.M. 1965. Shelterbelts and Windbreaks. Faber and Faber.

Grace J. 1977. Plant Response to Wind. Academic Press.

Russell G and Grace J. 1978. The Effect of Windspeed on the Growth of Grasses. J. Appl. Ecol. 16, 507-514.

Figure 2.
Hourly mean speed in metres per second exceeded for 50% of the time during the years 1965 - 73. Valid for a height of 10 metres above open level terrain (gust ratio 1·60) and for altitudes between 0 and 70 metres above mean sea level.

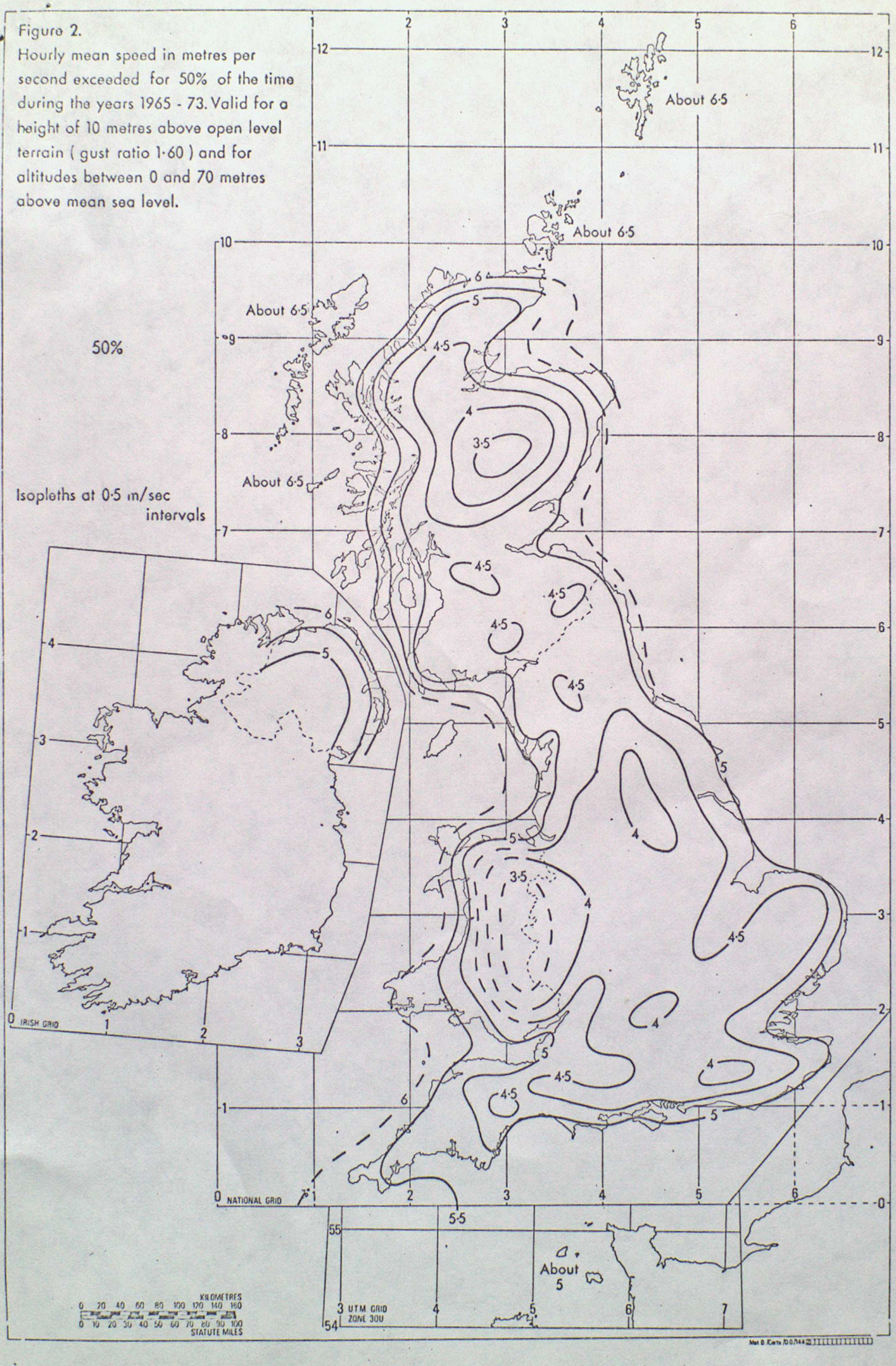
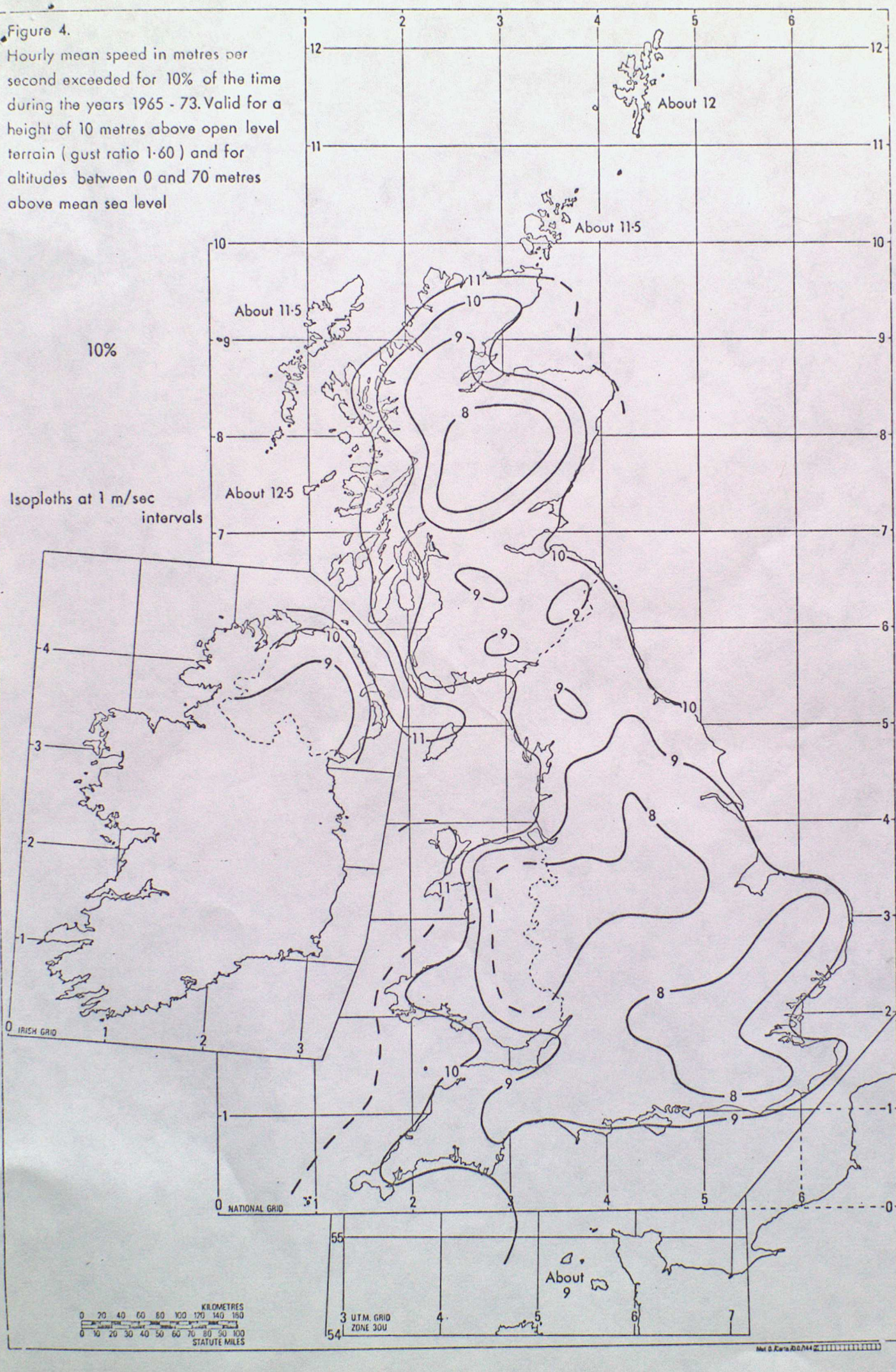


Figure 4.

Hourly mean speed in metres per second exceeded for 10% of the time during the years 1965 - 73. Valid for a height of 10 metres above open level terrain (gust ratio 1·60) and for altitudes between 0 and 70 metres above mean sea level



MAP OF YORKSHIRE & CLEVELAND ARABLE AREAS.

400 ft. (122 m.) CONTOUR.